Benefits of Training for the Development of Muscular Power in Older Adults

By Bryan Green and Graduate Student Mentor, Jeremy Ducharme

I. Introduction

Aging is strongly associated with gradual losses in skeletal muscle mass known as sarcopenia, which negatively impacts quality of life in the elderly (1). Loss of muscle mass can be detrimental for many abilities in the human body such as mobility, muscular strength, and muscular power (2). As these abilities diminish, the risk of falling increases, which may require hospitalization and extended rehabilitation, both of which are very costly (3). Methods have been developed to combat the declines in muscle mass and limit the associated risk of injuries. Exercise, specifically resistance training (RT) in the form of strength training, has been shown to improve muscle health and battle against the development of sarcopenia (2). While traditional forms of RT have been shown to be helpful, less is known on how other forms of RT may aid muscular strength and functional abilities of older adults. One method to consider is training for muscular power, as low muscle power is linked to functional limitations, disability, and falls (4). Power training (PT) is prescribed using light loads and moving them at high velocities, which can be beneficial as it is task specific for functional activity and benefits the quality of life in older adults (4). Although PT is well utilized in the general population, few have investigated how it can be beneficial and aid in quality of life for older adults (5). Due to limited research, there is a need to determine how developing power can benefit older adults and how exercise professionals can prescribe PT to an elderly population. Therefore, the purpose of this article is to provide information on how training for power can benefit older adults and how it can be prescribed for those of various functional abilities.

II. Muscular Power

Muscular power is defined as the ability to produce high amounts of force in a short amount of time and is calculated by multiplying force by velocity (6). Importantly, power is a spectrum with some movements requiring high amounts of power (i.e., pole vault) while others require a low amount of power to successfully perform (i.e., standing from a chair). Despite the lower relative power requirement, older adults may be limited to achieve adequate power to successfully perform these actions. Decreases in muscular power would delay such reactions, which can lead to increased risks of injury (7). Increasing an individual's maximal power may increase their ability to perform movements that require less power. Maximal muscular power is affected by many factors including motor unit recruitment, firing frequency, inter-muscular coordination, the time available to develop force, storage and utilization of elastic energy, interactions of contractile and elastic elements, potentiation of

contractile and elastic filaments as well as stretch reflexes (8,9). These factors are known to deteriorate with aging and may result in reduced quality of life (2).

Before PT should be prescribed, it is important to understand how force and velocity contribute to muscular power production. Muscular power is best described by the force-velocity relationship and the time available to develop force (8,9). The force-velocity properties of muscle are determined by the muscle fiber type in contribution to the muscle area. For example, type II muscle fibers have a greater capacity to generate power per unit cross-sectional area compared to smaller type I fibers (8,9). Type II muscle fibers are also known decline with aging at a much faster rate than type I muscle fibers, which is why it is important to prevent atrophy of type II muscle so maximal power outputs can be sustained. The ability for an older adult to produce maximal power outputs is determined by how fast they are able to exert high amounts of force. Conversely, as velocity increases, the force that the muscle can generate decreases during concentric muscle actions which demonstrates that one must also have sufficient strength to elicit force in order to achieve maximal muscular power (6). Considering this relationship, the amount of time at which force is developed, known as the rate of force development (RFD), should be considered. The RFD is how fast one can develop force and therefore is a direct measurement of power. Improving RFD may enhance daily functional-specific movements such as walking, standing, and catching oneself from a slip. It is important to understand how decrements of these factors can inhibit functional performance in older adults and issues related to the deficiency of muscular power (1).

III. Deficiency of muscular power and how it can benefit older adults

Insufficient levels of muscular strength and power present issues that can negatively impact the quality of life of older adults. It is important to understand the factors that are impacted by aging and sarcopenia, and how to treat these through developing muscular power. Factors to understand and should be considered during exercise programming to enhance power include: (1) muscle mechanics, (2) morphological factors, and (3) neural factors.

IIIa. Muscle Mechanics

The force-velocity relationships should be considered when attempting to understand issues with the deficiencies in muscular power. As velocity increases, force decreases, and the opposite occurs if force increases, and velocity decreases. Since power is the product of force and velocity, one must have both to produce power (8,9). If there are decreases in strength, then there are decreases in muscular power. By training at high velocities, the ability to develop force rapidly can be developed, which in turn, is muscular power. If this component is not trained efficiently, individuals may not be able to produce force fast enough for completing various functional movements. For some movements, such as

catching themselves from falling, older adults may not have the benefit of taking more time to generate force which may result in a fall that could have been avoided had proper PT been implemented.

IIIb. Morphological Factors

Contractile capacity of muscle is also a determinate of being able to generate maximal power and is influenced by morphological factors, specifically fiber type composition (8,9). The human body consists primarily of two types of muscle fibers, type I and type II (8,9). Type II fibers have a greater capacity to generate muscular power compared to type I muscle fibers. Importantly, type II fibers are more susceptible to atrophy during aging, which can decrease functional performance in older adults (1). Therefore, RT should be prescribed so that injuries associated with aging and atrophy of type II muscle fibers are minimized.

IIIc. Neural Factors

Neural factors are also highly involved in producing power (8,9). Neural drive must surpass the high recruitment thresholds of type II fibers in order for them to contract. Both type I and type II muscle fibers are activated at high force levels, which is explained by the size principle (8,9). The size principle states that motor units are recruited in a systematic order (smaller to larger fibers) during graded, voluntary contractions of increasing force (8,9). When producing maximal power, it is beneficial to be able to recruit high-threshold motor units as they innervate large numbers of high force-producing muscle fibers (8,9). Unfortunately, the ability to recruit high-threshold motor units is reduced with aging, which leads to decreases in functional performance.

Considering these various factors involved in maximal power production, it is important to consistently give a stimulus that is sufficient to activate type II fibers as these are largely responsible for the ability to develop higher levels of muscular power and preventing their atrophy. One way to achieve this is via velocity-based training, which uses RT at a low intensity and high velocity to enhance limb power and mobility in older adults (4). Before prescribing a program to develop muscular power, the baseline characteristics of the older adults must be assessed in order to have a program that will provide optimal benefits specific to their needs.

IV. Assessing Muscular Power

In older individuals, decreased lower extremity muscle power is strongly correlated with poor performance-based measures of physical function for daily living (10). Considering that lower extremity power is a predictor of impairment and fall risk in the elderly population, individuals should be assessed for lower body muscular power and prescribed programs to protect against injuries and increase function of these areas. Devices to assess muscular power include cycle ergometer, isokinetic dynamometry, unloaded leg extensor, and the use of dynamic pneumatic resistance training (10).

Importantly, not all elderly individuals have access to this equipment and may be limited due to their cost. To assess lower extremity power with limited equipment, older adults can be tested using the pneumatic power test protocol proposed by Callahan et al. (2007) which determines maximal lower body power as the highest of 5 attempts at achieving maximum power during two sets of one-repetition maximum (1-RM) leg press extensions. This method was shown to yield a significantly greater power compared to incremental single attempts and is highly reliable and well tolerable for older adults (10). After assessing an older adult for muscular power, a program to sustain or enhance functional performance can then be developed for the client's specific needs.

V. Power training programs for older adults to enhance functional performance

After a baseline assessment is complete, a program to enhance muscular power and functional performance can then be established. There are various methods that can increase muscular power and functional performance in older adults. Training for muscle strength and muscle power have shown to improve functional performance in older adults (7).

Increasing power can be achieved through using plyometrics with one's body weight, or through RT using light loads based off the individuals 1-RM. When using RT to enhance muscular power in older adults, using loads of 20%, 50%, or 80% of the 1-RM during high velocity contractions have shown to produce improvements in muscular power for healthy older adults (11). For safety precautions when training the elderly population, RT should be done on machine based equipment. Using plyometrics are another efficient movement that can be done without equipment and using one's body to enhance muscular power. Plyometrics such as counter-movement jumps (CMJ), non-countermovement jumps (NCMJ), and bounds with one's body weight can be used to train for power. Proper progression should be considered when implementing plyometrics for older adults to ensure safety. Fitness professionals should consider starting with NCMJ, progress into CMJ, and then into bounds as the individual becomes more accustomed to the stress of the movements. For improvements in muscular power, a general recommendation is that training programs should include a frequency of 3 times per week, with each training session lasting 30 minutes (7). In addition to training for power, older individuals should continue to train for improvements in muscular strength and balance as this may also increase increase functional performance and reduce risk of injury.

VI. Conclusion

Considering that muscular power decreases more rapidly than muscle strength with aging, it is crucial that older adults participate in RT programs that focus on developing muscular power. Training for power is a critical determinant of functional performance and aids in limiting the effects of sarcopenia, thereby reducing the risk of injury in older adults. Elderly individuals ($\geq$ 60 years) should be assessed

on their ability to produce muscular power and prescribed an individualized program to improve their functional performance. Findings of the current review demonstrate that using RT interventions that emphasize muscular power development is highly effective and safe for elderly populations. This type of training requires minimal equipment and is low cost, which makes it easily accessible to those who participate. Older adults needing to improve muscle power should participate in this type of training. It is important to progress elderly clients to the point where they are accustomed and can do this type of training at least three times a week. Considering the evidence, improving muscular power in older adults is beneficial for sustaining quality of life, improving functional performance, and limiting the risk of injury.

1) Apply It:

Health and fitness professionals should use machines such as the leg press machine and should perform high velocity contractions using intensities such as 20%, 50%, and 80% of their 1-RM to enhance muscular power when working with older adults.

When sufficient levels of strength, power, and balance have been achieved, health and fitness professionals can prescribe plyometric exercises such as jumps and bounds, which may be perceived as a more interesting way to develop power for older adults.

2) Bridging the Gap:

Development of power through resistance training can benefit older adults by combatting the effects of sarcopenia, sustaining quality of life, improving functional performance, and limit the risk of injury. Fitness professionals should assess their elderly clients and begin programming for the development of muscular power to limit the detrimental effects of aging.

3) Summary Statement:

Results of the current review demonstrate that improving muscular power in older adults is beneficial for sustaining quality of life, improving functional performance, and limiting the risk of injury.

4) Pulled text:

Considering that muscular power decreases more rapidly than muscle strength with aging, it is crucial that older adults participate in RT programs that focuses on developing muscular power

Bio:

Bryan J. Green, C.S.C.S., is completing his B.S. in Exercise Science at the University of New Mexico. His interests are helping various types of athletes increase their sports performance through strength and conditioning and participating in the sport of powerlifting.

References:

1. McCormick, R., & Vasilaki, A. Age-related changes in skeletal muscle: changes to life-style as a therapy. Biogerontology. (2018); 19(6), 519–536.
2. Lavin, K. M., Roberts, B. M., Fry, C. S., Moro, T., Rasmussen, B. B., & Bamman, M. M. The Importance of Resistance Exercise Training to Combat Neuromuscular Aging. Physiology (Bethesda, Md.). (2019). 34(2), 112–122.
3. Larsson, L., Degens, H., Li, M., Salviati, L., Lee, Y. I., Thompson, W., Kirkland, J. L., & Sandri, M. Sarcopenia: Aging-Related Loss of Muscle Mass and Function. Physiological reviews. 2019; 99(1), 427–511.
4. Bean, J. F., Kiely, D. K., LaRose, S., O'Neill, E., Goldstein, R., & Frontera, W. R. Increased velocity exercise specific to task training versus the National Institute on Aging's strength training program: changes in limb power and mobility. The journals of gerontology. Series A, Biological sciences and medical sciences. (2009); 64(9), 983–991.
5. Reid, K. F., & Fielding, R. A. Skeletal muscle power: a critical determinant of physical functioning in older adults. Exercise and sport sciences reviews. 2012; 40(1), 4–12.
6. Kawamori, N., & Haff, G. G. The optimal training load for the development of muscular power. Journal of strength and conditioning research. 2004; 18(3), 675–68
7. Gschwind, Y. J., Kressig, R. W., Lacroix, A., Muehlbauer, T., Pfenninger, B., & Granacher, U. A best practice fall prevention exercise program to improve balance, strength / power, and psychosocial health in older adults: study protocol for a randomized controlled trial. BMC geriatrics. 2013; 13, 105
8. Cormie, P., McGuigan, M. R., & Newton, R. U. Developing maximal neuromuscular power: Part 1--biological basis of maximal power production. Sports medicine. 2011; 41(1), 17–38.
9.Cormie, P., McGuigan, M. R., & Newton, R. U. Developing maximal neuromuscular power: part 2 - training considerations for improving maximal power production. Sports medicine (Auckland, N.Z.). 2011; 41(2), 125–146.
10. Callahan, D., Phillips, E., Carabello, R., Frontera, W. R., & Fielding, R. A. Assessment of lower extremity muscle power in functionally-limited elders. Aging clinical and experimental research. 2007; 19(3), 194–199.
11. de Vos, N. J., Singh, N. A., Ross, D. A., Stavrinos, T. M., Orr, R., & Fiatarone Singh, M. A. Optimal load for increasing muscle power during explosive resistance training in older adults. The journals of gerontology. Series A, Biological sciences and medical sciences. 2005; 60(5), 638–647.